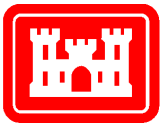
ERDC/EL TR-00-5



US Army Corps
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Reducing the Effects of Maintenance Dredging on Freshwater Mussels in the Alabama River, Alabama

Andrew C. Miller

June 2000

Environmental Laboratory

ERDC/EL TR-00-5
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Preface

The study herein was conducted by the U.S. Army Engineer Research and Development Center (ERDC) Environmental Laboratory (EL) for the U.S. Army Engineer District, Mobile. This report was prepared by Dr. Andrew C. Miller, Aquatic Ecology Branch (AEB), Ecological Research Division (ERD), EL.

Divers for this work were Messrs. Larry Neill, Dennis Baxter, Rob James, and Bennie Kerley of the Tennessee Valley Authority. Assistance in the field was provided by Messrs. Will Green and Mike Guilfoyle, University of Southern Mississippi, Hattiesburg, Mississippi, and Brian Watson, University of Louisville, Louisville, Kentucky. Maps and background information on the project area were provided by Ms. Beverley Stout, U.S. Army Engineer District, Mobile, Mobile, Alabama, and Mr. Paul Hartfield, U.S. Fish and Wildlife Service, Jackson, Mississippi.

During the conduct of this study, Dr. John W. Keeley was Acting Director, EL; Dr. Conrad J. Kirby was Chief, ERD; and Dr. Alfred F. Cofrancesco was Chief, AEB.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL Robin R, Cababa, EN, was Commander.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	meters
miles (U.S. nautical)	1.852	kilometers

1 Introduction

Background

On 1 October 1997, the U.S. Army Engineer District, Mobile, pursued recertification of the operations and maintenance plan and the previously approved maintenance dredging and disposal plan for small-boat access channels in the Alabama River, Alabama. The existing project provides for maintenance dredging of the Federally authorized navigational channel which is 9 feet (ft) deep and 200 ft wide. The waterway includes approximately 289 miles between the confluence of the Alabama and Tombigbee rivers upriver to Montgomery, Alabama. The proposed action would be executed with a hydraulic pipeline dredge, dragline, or clamshell between May and December. Dredged material would be placed at previously approved within-bank disposal areas.

Proposed dredging and disposal of material could negatively affect freshwater mussels (Family: Unionidae), a resource with economic, ecological, and cultural value. In medium- to large-sized rivers, these organisms usually reach their highest density in shallow water close to shore and outside the navigation channel. They are most common in sand/gravel substratum that is kept relatively free of silt with moderate- to high-velocity water, 0.5 to 1.5 ft/sec. Mussels are virtually nonmotile, require a fish host to successfully reproduce, and feed by filtering organic matter out of the water column. Shells of many species were used to make buttons before the advent of plastics; today, shells of certain species are used in the cultured pearl business. Williams et al. (1993) listed nearly 300 species of freshwater mussels in this country; 71.7 percent were considered to be endangered, threatened, or of special concern.

Potamilus inflatus, the inflated heelsplitter mussel, was listed as threatened in 1990 by the U.S. Fish and Wildlife Service. A fresh-dead shell of this species was collected on the Alabama River at River Mile (RM) 20.5 (Hartfield and Garner 1998). This mussel typically inhabits fine-grained, stable substratum in slow to moderate currents (Stern 1976; Hartfield 1988a,b). *Potamilus inflatus* has also been collected alive in the Amite River, Louisiana (U.S. Fish and Wildlife River 1994), the Black Warrior and Tombigbee rivers, Alabama (Miller 1994), and the Pearl River, Mississippi (Miller and Payne 1996; George, Dickerson, and Reine 1995).

In 1998, Hartfield and Garner (1998) sampled a series of sites in the lower Alabama River, RM 0 to 125. The purpose was to locate beds in the river and to provide preliminary information on relative abundance and number of species at each site. Based on this survey, the Mobile District agreed to obtain detailed information on four mussel beds. The intent was to obtain detailed information on density, community composition, and species diversity and to accurately map the location of each bed. This would be completed so that future dredging and disposal operations would not inadvertently damage mussels.

Purpose and Scope

The purpose herein is to report on community and population dynamics at four mussel beds in the Alabama River, located at RM 20.2-20.4, 30.1-30.4, 121.8-122.6, and 124.4-124.9. The exact location of each bed was mapped using information from divers and a global positioning system (GPS).

2 Study Area and Methods

Study Area

Studies were conducted at four mussel beds, two in the lower river, and two in the upper river (Table 1, Figures 1-8). The most downriver bed, RM 20.2-20.4, was along the right-descending bank (RDB) immediately downriver of a sandbar probably created from dredged material. The mussel bed was in a straight reach of river immediately downriver of a sharp left turn. The bed was narrow, within 25 meters (m) of the shore, and in water between 3 and 5 m deep. The shoreline was steep, well vegetated, and stable. At this site, a fresh-dead *Potamilus inflatus* was collected in 1998 by Hartfield and Garner (1998). This reach is dredged every 2 years.

Table 1
Location of Mussel Beds Surveyed in September 1998, Alabama River

River Mile			Coordinates[1]		
Downriver	Upriver	River Bank	Latitude	Longitude	Water Depth, m
20.2	20.4	RDB	N 31 16.275	W 87 49.007	5
30.1	30.4	RDB	N 31 16.951	W 87 49.894	4
121.	122.6	RDB	N 31 59.240	W 87 28.035	5
124.4	124.9	RDB	N 32 01.251	W 87 27.772	5

[1] Coordinates recorded near center of each bed.

The mussel bed at RM 30.1-30.4 was located on the RDB immediately upriver of a gradual left turn. A dredged-material disposal area was located on the left-descending bank (LDB) starting at approximately RM 30.4. Water was between 3 and 4 m deep. This bed, and the one located at RM 20.2-20.4, were accessed from a boat ramp on the LDB at Dixie Landing near RM 27.5. This river reach is dredged annually.

The bed at RM 121.8-122.6 was located along the RDB immediately upriver of a sharp left turn. Adjacent to the bed, the riverbank was steep

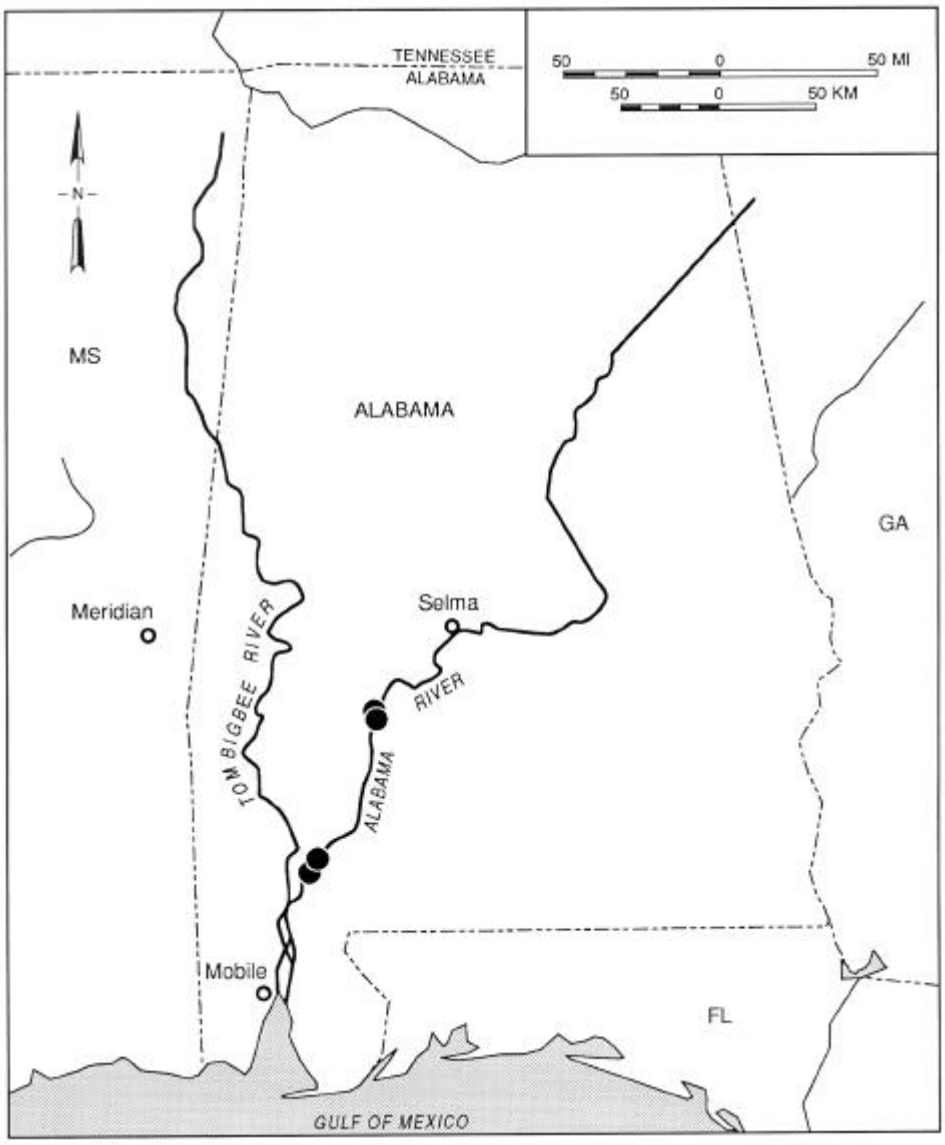

Figure 1. Map of the study area (mussels were collected at beds marked with solid circles)

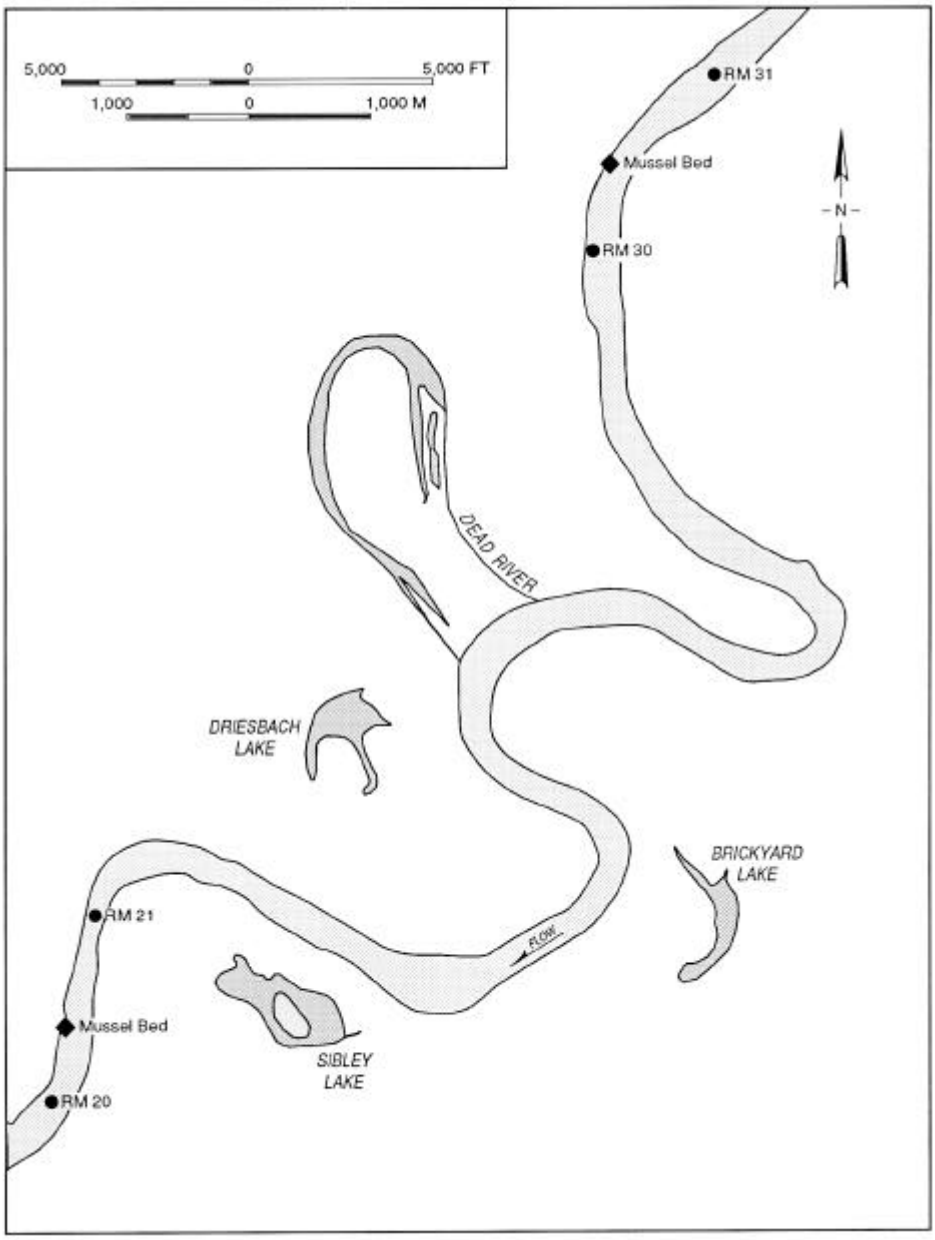

Figure 2. Area map for mussel beds at RM 20.2-20.4 and 30.1-30.4

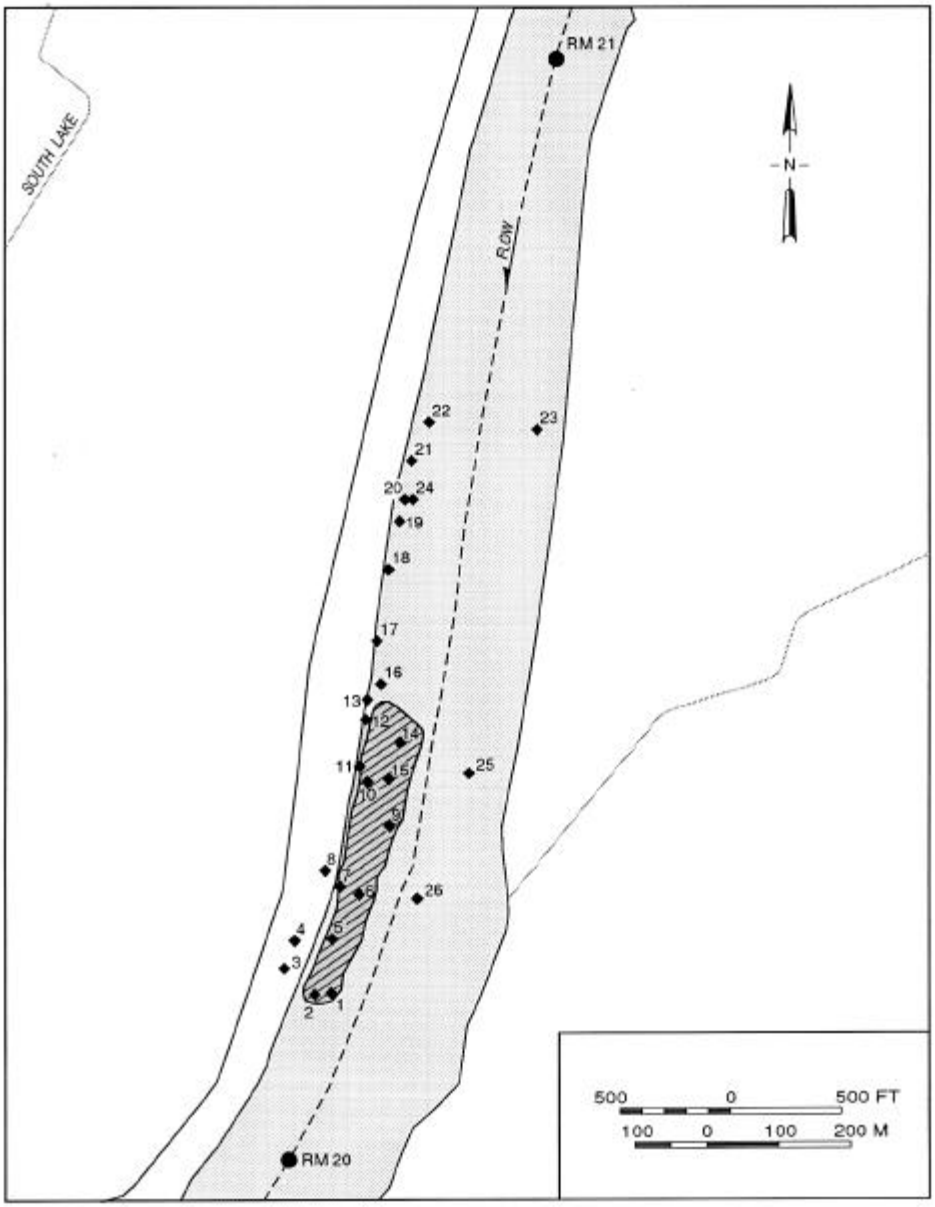

Figure 3. GPS coordinates for the mussel bed at RM 20.2-20.4

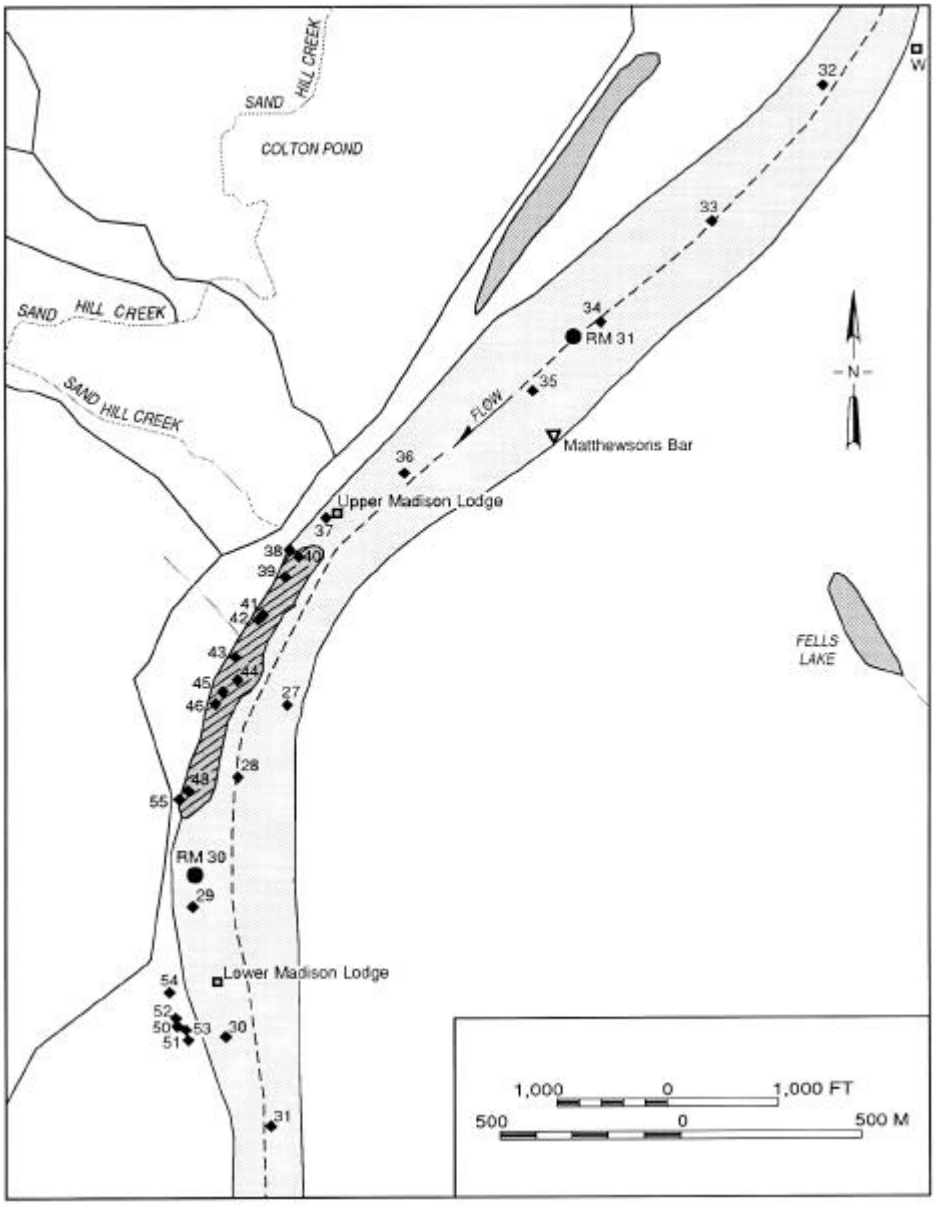

Figure 4. GPS coordinates for the mussel bed at RM 30.1-30.4

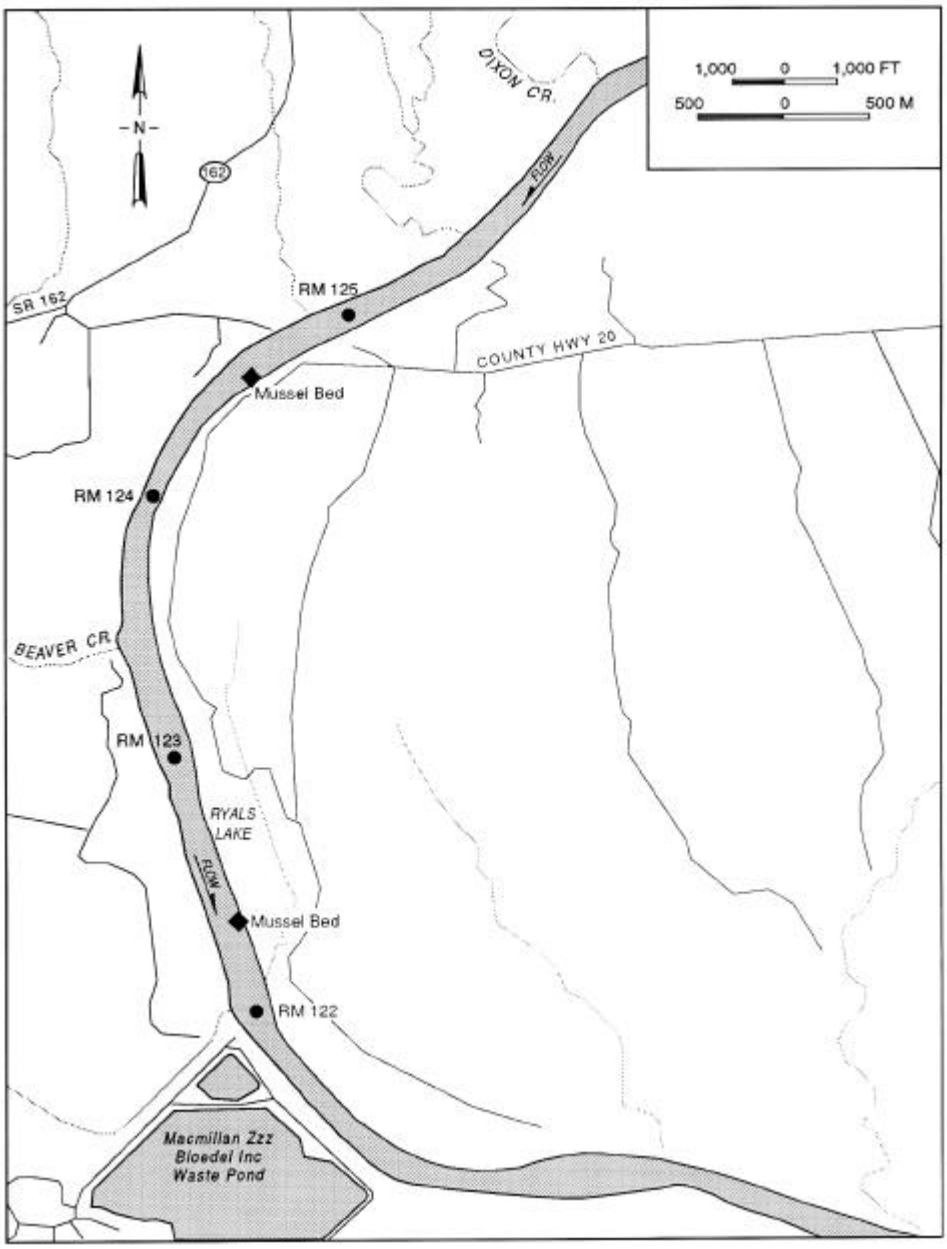

Figure 5. Area map for mussel beds at RM 121.8-122.6 and 124.4-124.9

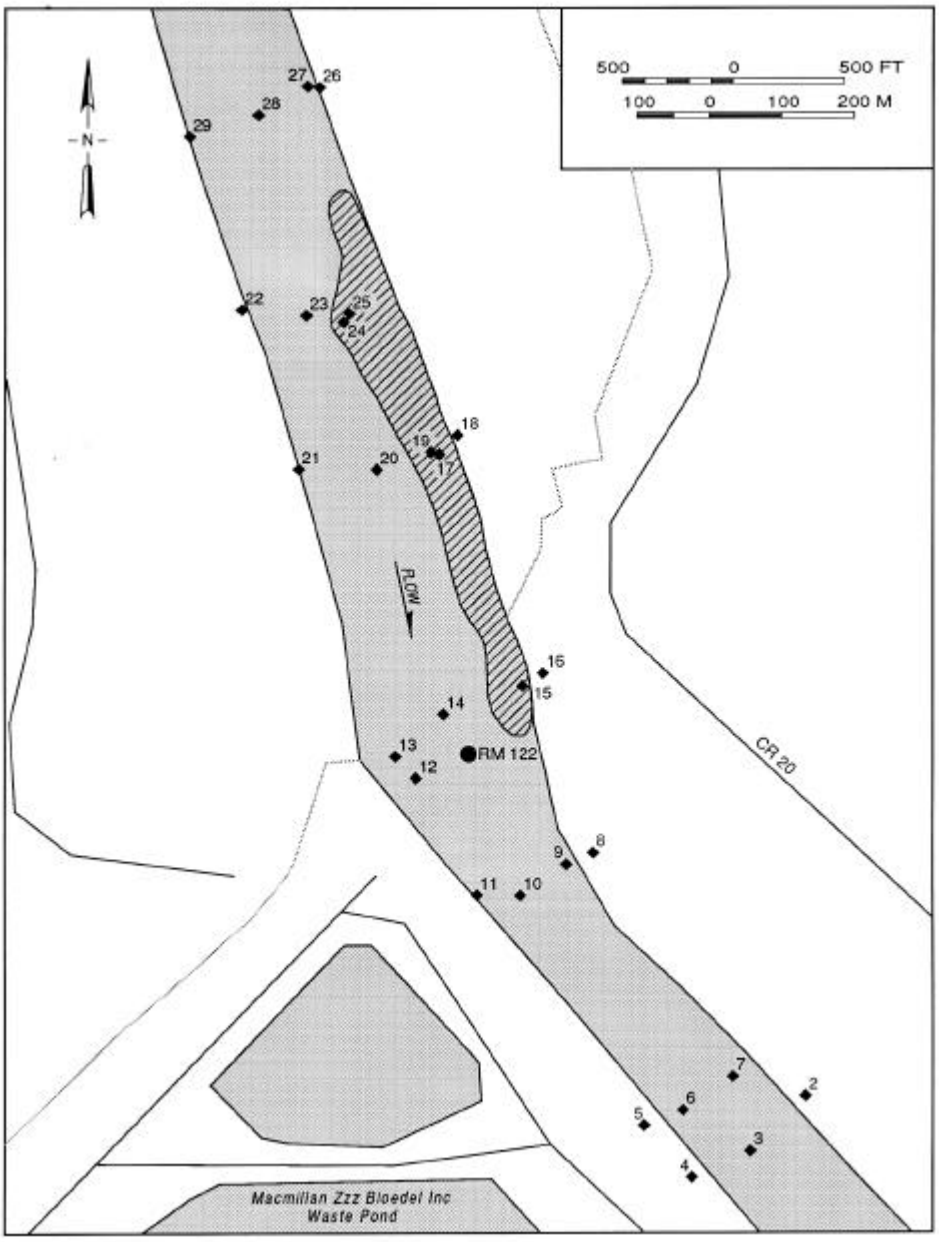

Figure 6. GPS coordinates for the mussel bed at RM 121.8-122.6, downriver section

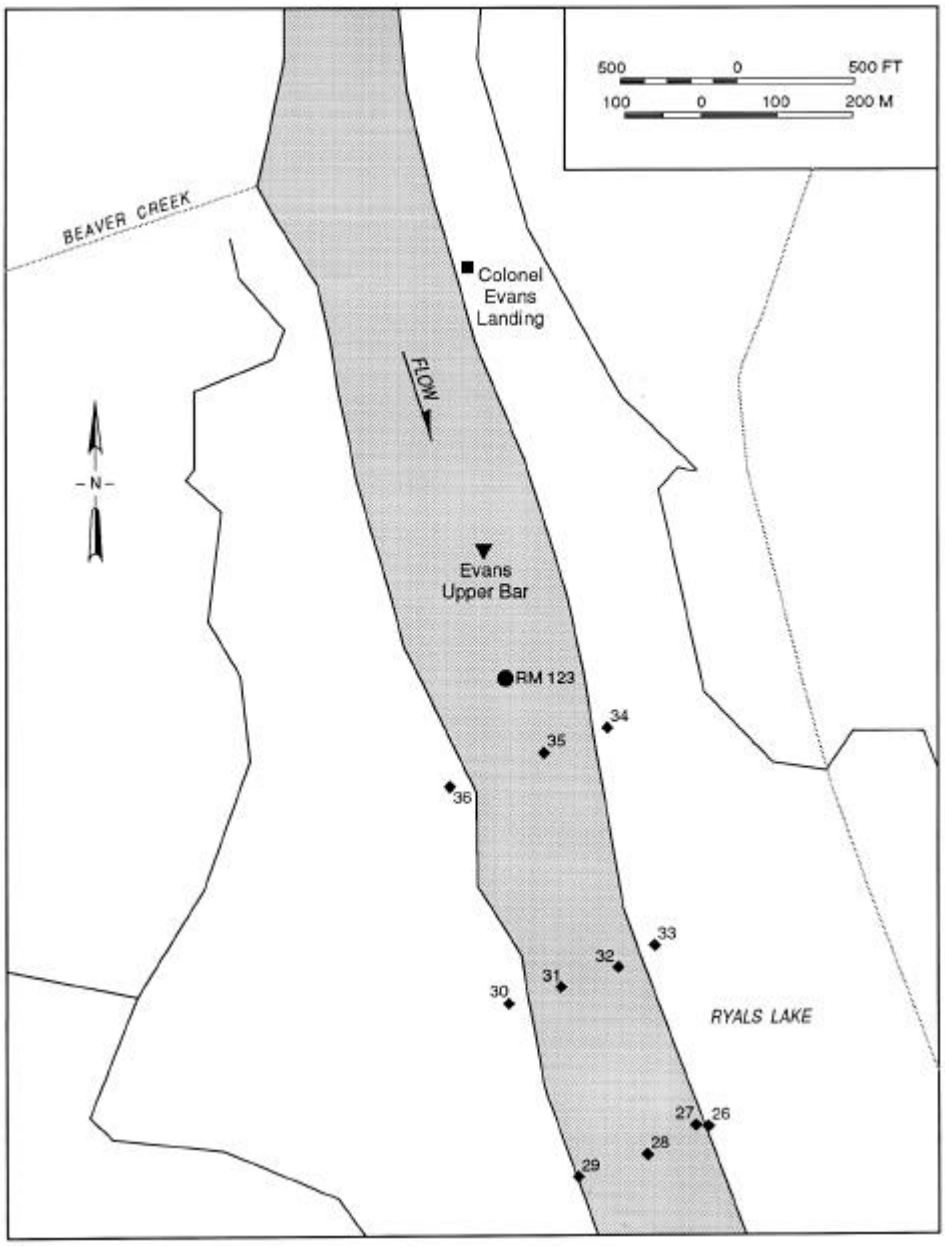

Figure 7. GPS coordinates for the mussel bed at RM 121.6-122.6, upriver section

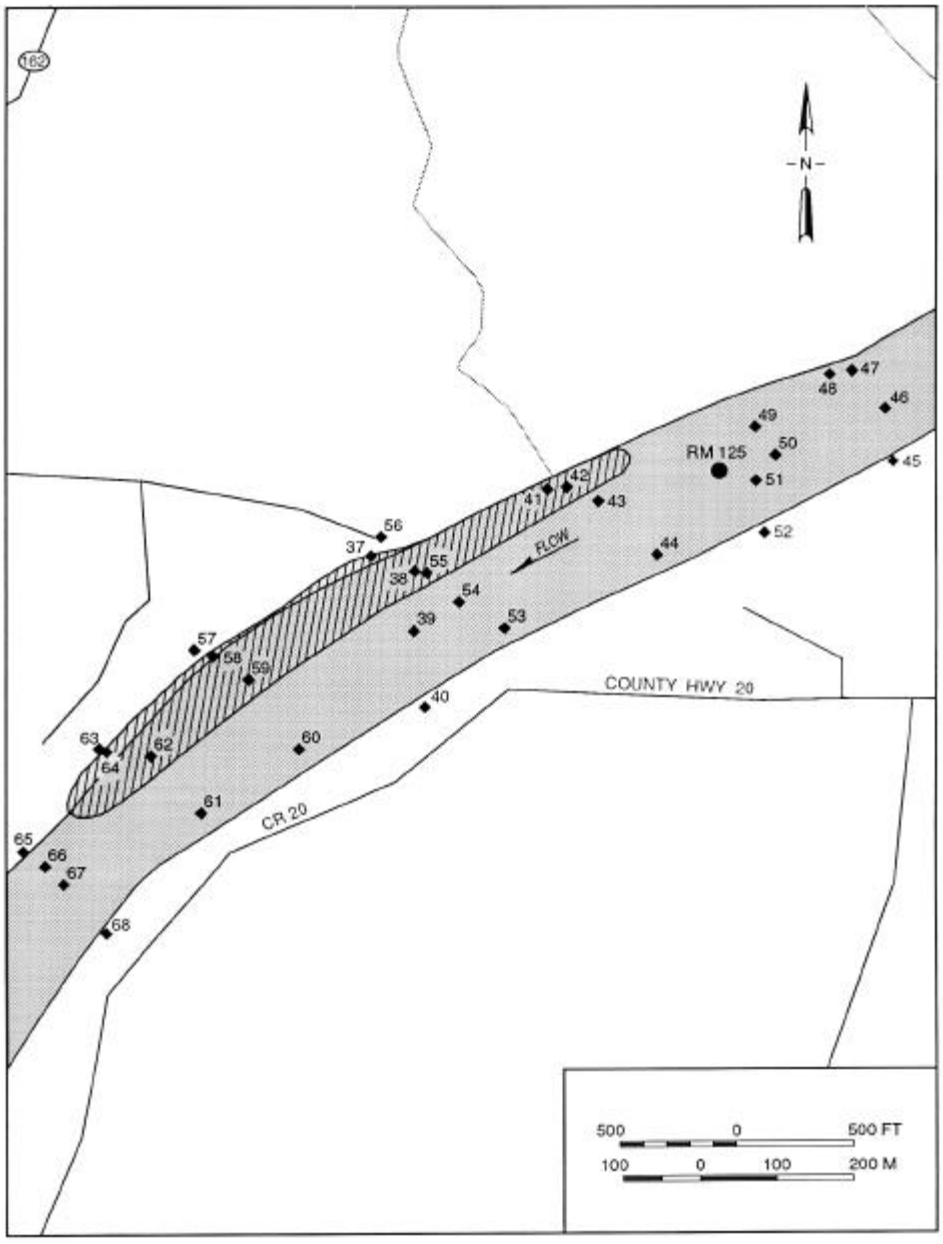

Figure 8. GPS coordinates for the mussel bed at RM 124.4-124.9

and eroded. A dredged-material disposal area was located immediately across the river, on the LDB. This river reach is dredged once every 10 years.

The most upriver bed, located at RM 124.4-124.9 was located on the RDB immediately upriver and downriver of the boat ramp at Clifton Ferry. Adjacent to the mussel bed, the riverbank was less than 45 deg, stable, and well vegetated. Moving downriver, the bank along the RDB was steeper with less vegetation. The mussel bed ended at the point that the slope of the bank approached 90 deg. This bed and the one located at RM 121.8-122.6 were accessed from a boat ramp at RM 118.4, LDB at Holley's Ferry, adjacent to Alabama Highway 10.

Methods

In the field, each mussel bed was located based on information in Hartfield and Garner (1998) and preliminary data obtained via reconnaissance dives. Study sites for qualitative and quantitative sampling at each bed were then identified. Twenty quantitative samples, 10 at each of two closely placed subsites, were obtained near the center of each bed. After quantitative samples were obtained, qualitative collections were obtained by two divers. All sampling was done near the center of each mussel bed.

Quantitative samples were collected by a dive crew with surface-supplied air and communication equipment. A single diver excavated all sand, gravel, and shells from within a 0.25-m^2 aluminum quadrat. The 10 quadrats for each subsite were positioned in a 2 by 5 matrix and were placed approximately 0.25-0.5 m apart. Divers transferred substratum to a 20-L bucket, which was then carried to shore and sieved through a screen series with the finest apertures, 6.4 mm. Total shell length of live mussels was measured in the field or else preserved in 10 percent formaldehyde and returned to the laboratory for processing.

Qualitative samples were obtained by having two divers obtain a total of 12 samples of mussels. Divers retrieved all mussels encountered by touch since there was essentially no visibility in the river. Mussels were transported to shore, identified, and then returned to the river unharmed. Unionid nomenclature followed Williams et al. (1993).

Location data needed to prepare a map of each mussel bed were collected by two individuals in a small boat using a hand-held GPS (Garmin GPS12XL Personal Navigator). The exact location of the beds was based on information from the divers and data on sediment types obtained with bottom samples made with a petite ponar dredge. Coordinates saved while in the field, in conjunction with maps stored in *Street Atlas Version 6.0*, were used to produce maps of the study area and each mussel bed. Based upon information provided by Garmin, Inc., there can be an error of approximately 5-100 m when using this equipment. Some of the points

recorded on the maps made for this survey (Figures 3, 4, 6, 7, and 8) are outside the river channel. This could be the result of that error or the fact that the water level was high when this work was done and actual sites surveyed might have been outside the channel as described on maps in *Street Atlas Version 6.0.*

3 Results and Discussion

Existing Conditions

A total of approximately 1,500 mussels representing 13 species were collected at the four mussel beds in the lower Alabama River in 1998 using quantitative methods (Table 2, Appendix A). The ebony shell (*Fusconaia ebena*), Alabama orb (*Quadrula asperata*), and threehorn wartyback (*Obliquaria reflexa*) were most abundant and represented 76.2, 12.6, and 5.7 percent of the collection, respectively. These three species plus the butterfly (*Ellipsaria lineolata*) were found at all four mussel beds. The mussel assemblage at all mussel beds was not diverse; more than 90 percent of the community was composed of only three species. The remaining 10 species were much less common; each represented less than 2 percent of the collection. Overall species diversity (Shannon's diversity index, H') for each mussel bed, based on 20 samples, ranged from a low of 0.81 at RM 124.4 to a high of 1.63 at RM 20.2. The minimum number of species collected was 7 (the bed at RM 30.1-30.4), and the maximum was 10 collected at the bed at RM 121.8-122.6 and the bed at RM 124.4-124.9. Density at the most downriver two beds was low (less than 25 individuals/m^2), whereas at the two upriver beds was greater than 100 individuals/m^2. Although beds differed with respect to total density, recruitment rates were similar at all locations. No Federally listed endangered or threatened species were collected at any of the mussel beds.

There is little recent information on freshwater mollusca of the Alabama River. Van der Schalie (1981) listed species from the river, citing works of Hartman and Call from the main stem and H. H. Smith for information on selected tributaries. Van der Schalie listed 10 species, 3 of which were collected during the 1998 survey.

Table 2
Summary Information on Freshwater Mussels Collected at Four Mussel Beds in the Alabama River, 1998 (X = Live organisms present; R = Live organisms present with total shell length less than 30 mm (evidence of recent recruitment))

Species	Common Name	Abundance	Frequency	River Mile			
				20.2-20.4	30.1-30.4	121.8-122.6	124.4-124.9
Fusconaia ebena	Ebonyshell	76.25	81.25	R	R	R	R
Quadrula asperata	Atlantic orb	12.61	76.25	R	X	R	R
Obliquaria reflexa	Threehorn wartyback	5.66	57.50	R	R	R	R
Ellipsaria lineolata	Butterfly	1.80	26.25	X	X	R	R
Fusconaia cerina	Gulf pigtoe	1.09	16.25			R	R
Quadrula apiculata	Southern mapleleaf	0.90	12.50		X	X	X
Truncilla donaciformis	Fawnsfoot	0.84	15.00	X		R	R
Leptodea fragilis	Fragile papershell	0.19	3.75			X	X
Elliptio crassidens	Elephant-ear	0.13	2.50	X		X	
Plectomerus dombeyanus	Bankclimber	0.13	2.50		X	X	
Quadrula metanevra	Monkeyface	0.13	2.50	X			X
Lampsilis ornata	Southern pocketbook	0.13	2.50	X	R		
Megalonaias nervosa	Washboard	0.13	2.50				X
Total individuals		1,554					
Total species		13		8	7	10	10

Demographic Studies

Fusconaia ebena

Sufficient numbers of individuals were collected for reasonably detailed length-frequency histograms of this species at RM 30.5, 122.0, and 125.0 (Figure 9). The assemblages of *Fusconaia ebena* at these three sites were strikingly similar in size structure, indicating intersite uniformity in patterns of recruitment, growth, and longevity. At all three locations, the most abundant size class of mussels were those in the 50- to 65-millimeter (mm) shell length (SL) range. Most clearly at RM 121.8-122.6, but also at RM 30.1-30.4 and 124.4-124.9, mussels from 15-30 mm and from 70-85 mm were moderately abundant. Although a single individual >120 mm long was obtained at RM 121.8-122.6, most mussels ranged from a minimum length of approximately 10 mm to a maximum of approximately 85 mm. At RM 20.2-20.4, only 11 individuals were obtained. However, even these few individuals approximately spanned the full size range observed at the other locations and even tended to suggest the same clustering of abundance at 15-30 mm, 50-65 mm, and 70-85 mm. Thus, it is likely that recruitment, growth, and longevity patterns at RM 20.2-20.4

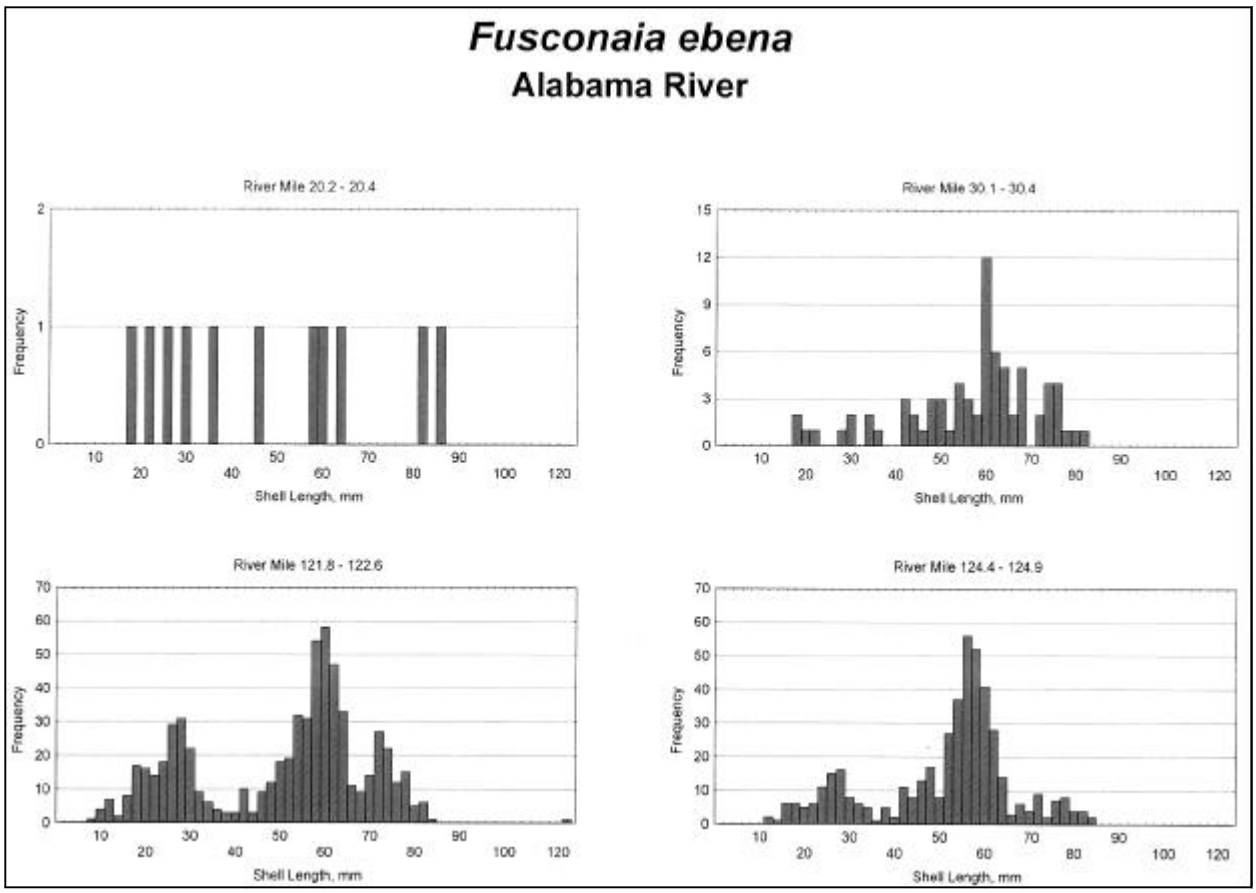

Figure 9. Size demography for *Fusconaia ebena* at four locations in the Alabama River, 1998

are similar to patterns at the other sites. If more than 30 individuals had been obtained at this low-density site, it is likely that the length-frequency histogram would have been very similar to the other three sites.

Based on these observations, it is appropriate to represent size structure of the *Fusconaia ebena* population(s) of the Alabama River using a composite representation of all sites. Combing sites allows a greater number of individuals in the length-frequency histogram, and, consequently, a higher level of detail. The spacing of modes in the frequency histogram for relatively small mussels indicates the annual growth increment (approximately 8-9 mm per year for this species in its first several years of life in the Alabama River). Three young cohorts appear to be centered at approximately 11, 19, and 28 mm. Relative abundance of these three cohorts followed the order 28>19>11. Assuming 1998 recruits were too small to be retained on the smallest sieve used to process samples, the cohorts with modal SL equaling 11, 19, and 28 mm probably represent 1997, 1996, and 1995 recruitment, respectively.

Mussels grow less rapidly as they age, and adjacent cohorts tend to overlap enough that they are difficult to individually distinguish at

>50-mm SL. Regardless, abundance of mussels 54-64 mm long indicates especially strong recruitment a few years (perhaps around 1990) prior to 1995.

Quadrula asperata

Upon initial examination, length-frequency histograms for *Quadrula asperata* suggest a lack of recent recruitment at RM 20.2-20.4 and 30.1-30.4 compared with 121.8-122.6 and 124.4-124.9 (Figure 10). However, such a conclusion is tenuous for two reasons. First, the relatively low density of this species at RM 20.2-20.4 and 30.1-30.4 led to far fewer individuals (total n = 15 and 19, respectively) in quantitative samples than at RM 121.8-122.6 and 124.4-124.9 (total n = 94 and 68, respectively). Second, at the two sites with high-density populations, large mussels (>40 mm) were 2.9 to 3.3 times more abundant than small mussels (<40 mm). Thus, if size structure actually did not vary much among sites, only a few individuals <40 mm long (perhaps 4-6) would be expected among the relatively small samples of this species at the low-density sites

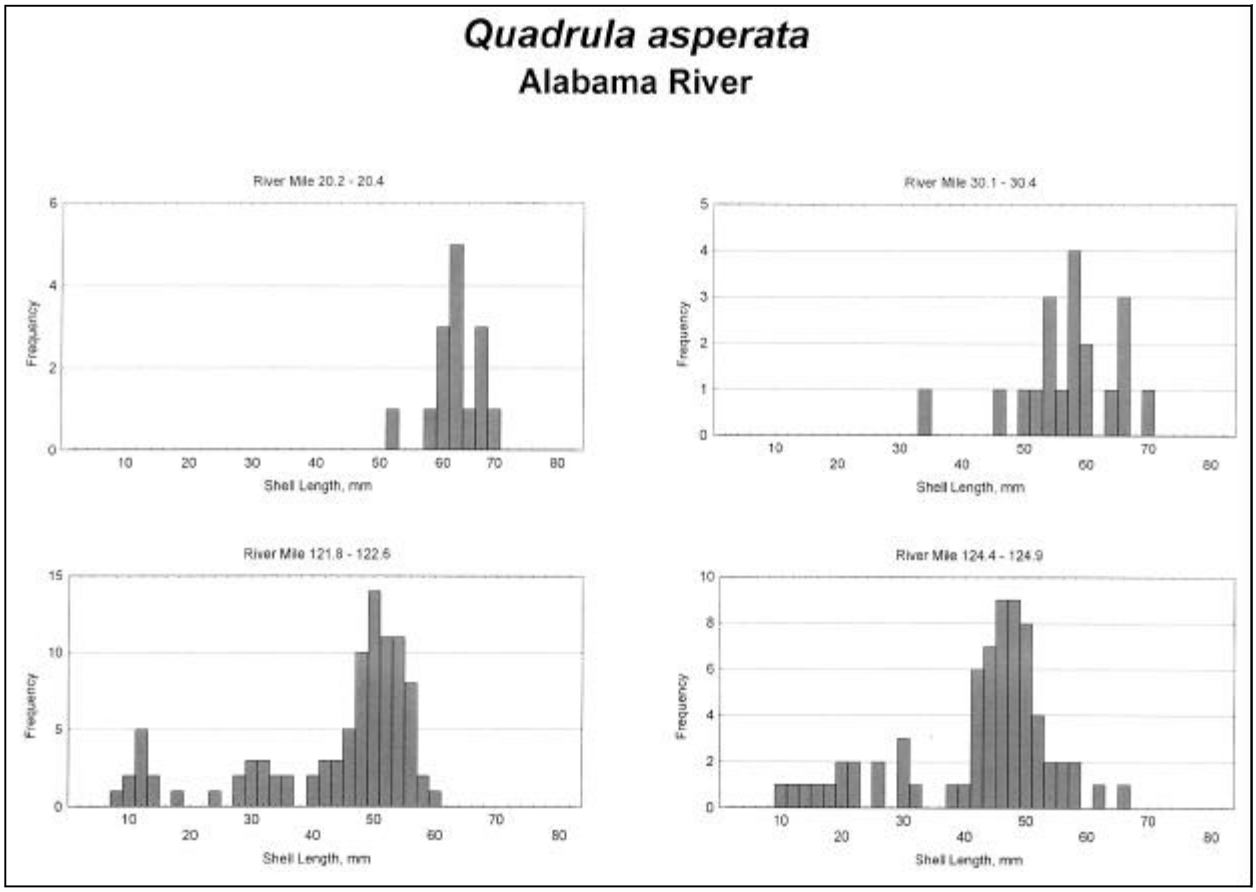

Figure 10. Size demography for *Quadrula asperata* at four locations in the Alabama River, 1998

at RM 202-20.4 (total n = 15) and 30.5 (total n = 19). One individual <40 mm long was obtained at RM 30.1-30.4, and none were obtained at RM 20.5. It is not justified to conclude that there is a lack of recent recruitment at RM 20.2-20.4 and RM 30.1-30.4; however, recruitment at these two sites is less than expected based on ratios of small-to-large mussels at RM 121.8-122.6 and RM 124.4-124.9.

Obliquaria reflexa

Relatively small samples of this species were obtained at all sites (Figure 11). Quantitative samples at all mussel beds yielded 10, 7, 34, and 37 individuals, respectively. Thus, only the high-density sites (RM 121.8-122.6 and 124.4-124.9) provide much detail. *Obliquaria reflexa* at these sites ranged from 14 to 68 mm long. Individuals 40-60 mm long were most abundant.

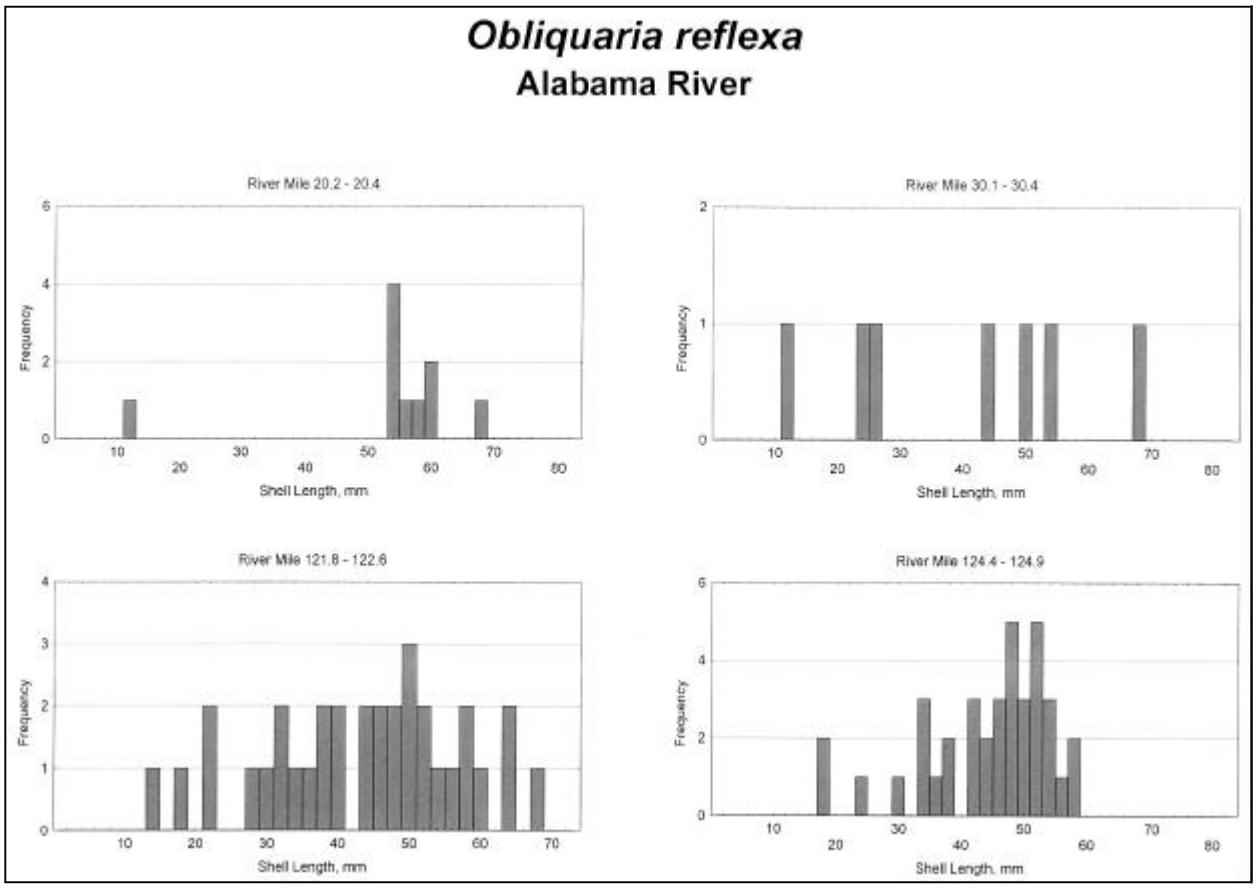

Figure 11. Size demography for *Obliquaria reflexa* at four locations in the Alabama River, 1998

Description of Mussel Beds

Mussel bed located between RM 20.2 and 20.4, RDB

Mean density at RM 20.2 (Figure 3), 8.8 mussels/m^2, was lower than at any of the other beds (Figure 12). A total of eight species were collected at this location, which was strongly dominated (more than 80 percent) by *Quadrula asperata*, *Fusconaia ebena*, and *Obliquaria reflexa*. On average, approximately two species were collected per quadrat (Figure 13). There was some evidence of recent recruitment; three species and 13.6 percent of the individuals collected were less than 30 mm total shell length. Evidence of recent recruitment was found for *Fusconaia ebena*, *Obliquaria reflexa*, and *Truncilla donaciformis*.

Hartfield and Garner (1998) collected 94 mussels and eight species at this location. The dominant species was *Quadrula asperata*. A fresh-dead *Potamilus inflatus* (the inflated heelsplitter, Federally listed as endangered) was collected at this site, which was the only recent find of this species in the Alabama River. This species was not catalogued in the collection of Tulane Museum of Natural History (1964-1974) but was reported by E. A. Smith in 1876 (Hartfield and Garner 1998).

This bed is narrow and located close to the right-descending bank between coordinate numbers 4 and 13 (Appendix B). It is located immediately downriver of a disposal area located on the RDB between

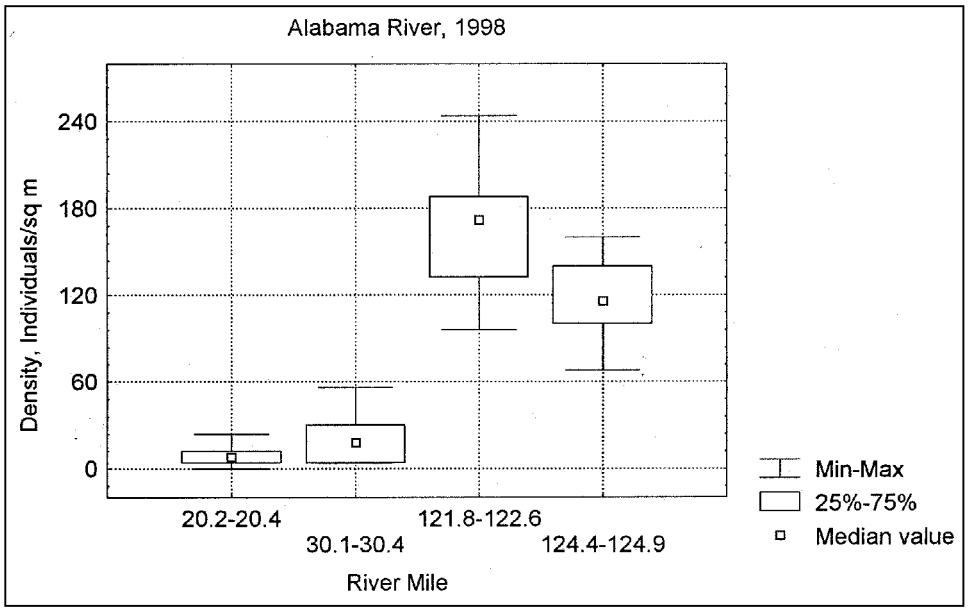

Figure 12. Mean mussel density (individuals/m^2) at four locations in the Alabama River, 1998

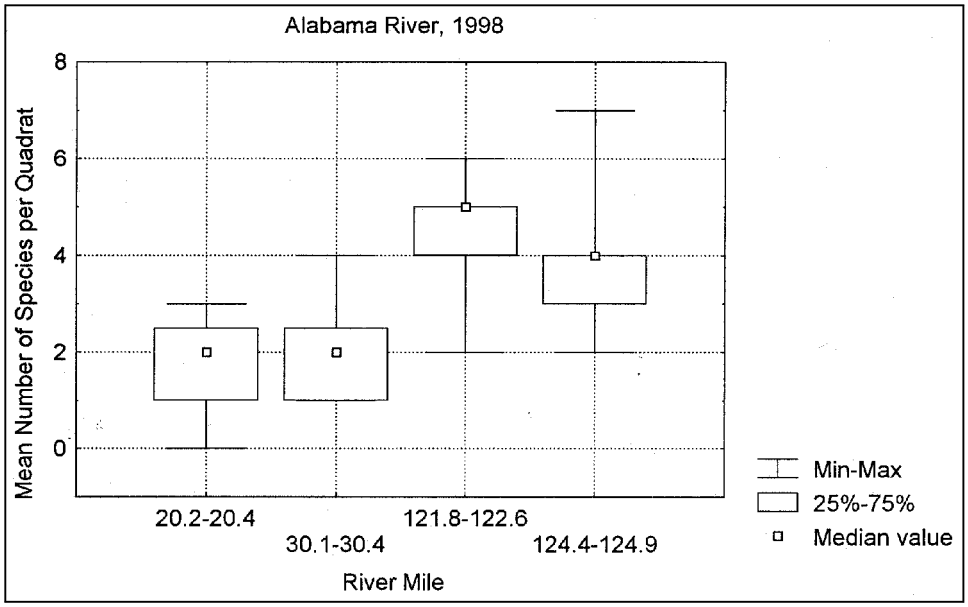

Figure 13. Mean number of mussel species per 0.25-m^2 quadrat at four locations in the Alabama River, 1998

coordinates 18 and 26. Although this bed exhibits low density in comparison with the other beds located upriver, it is still worthy of protection. Not only does it show evidence of recruitment but a fresh-dead *P. inflatus* was collected there in 1998. Further protection could be given to this bed by placing dredged material at the extreme upriver portion of the existing disposal area (located at approximately RM 20.5). Placing the material at the upriver portion of the bed would protect the usually more valuable, downriver sections that tend to be more depositional and, therefore, valuable for mussels. Alternatively, an entirely new location could be found for dredged material.

Mussel bed located between RM 30.1 and 30.4, RDB

Mean density at RM 30.1 (Figure 4) was 2-3 times greater ($21/m^2$) than at the previously discussed bed located downriver (Figure 12). Only seven species were collected, and the fauna was dominated by *Fusconaia ebena* and *Quadrula asperata*, which together comprised approximately 80 percent of the community (Figure 13). Three of seven species and 10 percent of the individuals collected showed evidence of recent recruitment. Approximately two species were collected per quadrat (Figure 13). Evidence of recent recruitment was found for *Fusconaia ebena*, *Obliquaria reflexa*, and *Lampsilis ornata*.

This is a fairly narrow bed located along the RDB at the start of a left turn in the river between GPS coordinates 39 and 55. The disposal area is located along the LDB, between RM 31.4 and 29.8, GPS numbers 27 to 37. Although this mussel bed is close to the disposal area, because it is

located along the opposite bank, it is less likely to be negatively affected by disposal. The bed could be best protected by placing material at the extreme upper end of the disposal area.

Mussel bed located between RM 121.8 and 122.6, RDB

At RM 121.8 (Figure 6), the mean density was much higher than at the previous two sites, 180 individuals/m^2 (Figure 12). Ten species were collected, and the fauna was strongly dominated by *Fusconaia ebena* and *Quadrula asperata*, which comprised approximately 80 percent of the fauna. More than 25 percent of the fauna were less than 30 mm total shell length, and six species showed some evidence of recent recruitment. On average, more than six species were collected per quadrat (Figure 13). Evidence of recent recruitment was found for *Ellipsaria lineolata*, *Fusconaia ebena*, *Obliquaria reflexa*, *Truncilla donaciformis*, *Quadrula asperata*, and *Fusconaia cerina* (Gulf pigtoe). Community composition and evidence of recent recruitment were similar to the other two beds, although this bed was notable for its extremely high density.

This is also a narrow bed located along the LDB between GPS coordinates 27 and 9. The dredged-material disposal area is located along the RDB at approximately RM 122. Disposal of dredged material along the RDB is unlikely to negatively affect the bed. However, dredging along the LDB could negatively affect the mussels.

Mussel bed located between RM 124.4 and 124.9, RDB

Mean density at the most upriver mussel bed (Figures 7 and 8) was 116.8 individuals/m^2, which was slightly less than at the previous beds, but substantially more than the two beds located farther downriver (Figure 12). As with the previous two locations, this bed was dominated by *Fusconaia ebena* and *Quadrula asperata*, which made up more than 80 percent of the community. Overall, 17 percent of the individuals and 6 out of 10 species were less than 30 mm total shell length. Slightly less than four species were collected per quadrat. Evidence of recent recruitment was found for *Ellipsaria lineolata*, *Fusconaia ebena*, *Fusconaia cerina*, *Obliquaria reflexa*, *Truncilla donaciformis*, and *Quadrula asperata*.

This bed is along the RDB from GPS number 42 to just upriver of number 65. The bend ends just as the bank on the right side becomes steep and approaches a 90-deg slope. Densities at this bed are extremely high, although community composition and evidence of recent recruitment were similar to the other mussel beds downriver.

Concluding Comments

The most interesting finding of this survey was the fairly high density, 164.0 and 116.8 individuals/m^2 at RM 121.8-122.6 and 124.4-124.9, respectively. Although high-density beds such as these have been located in the Sunflower (Miller, Payne, and Hartfield 1992) and lower Tennessee rivers (Way, Miller, and Payne 1989), many mussel beds in medium-sized to large rivers in the central United States have total mean densities less than 100 individuals/m^2. Evidence of recent recruitment was found for 7 of the 13 species collected alive, *Fusconaia ebena*, *Fusconaia cerina, Obliquaria reflexa*, *Truncilla donaciformis*, *Lampsilis ornata, Ellipsaria lineolata*, and *Quadrula asperata*. At the four mussel beds, the total number of individuals that were less than 30 mm total shell length (evidence of recent recruitment) ranged from 4 to 29 percent. Certainly recruitment rates are good at these beds, although not exceptional. At a high-density bed in the lower Ohio River during one year, more than 70 percent of the *F. ebena* were less than 30 mm total shell length (Payne and Miller 1989). Compared with other mussel beds in the southeastern United States, these beds in the Alabama River had relatively low-diversity indices (Shannon's diversity index), which was a function of the high dominance of relatively few species.

Moderate-to-high-density assemblages of mussels with good evidence of recent recruitment, such as were found at these four beds, are an important component of the mussel resource in this country. As such, they can be damaged by deposition of sand and gravel from dredging operations. As an aid to protecting these beds, their position has been carefully mapped so the effects of disposal of dredged material can be minimized.

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Appendix A
Results of Quantitative Sampling at Four Mussel Beds in the Alabama River, 1998

Table A1
Summary Statistics for Data on Freshwater Mussels Collected Using Quantitative Methods at Alabama River Miles 20.2-20.4, September 1998

Species	Common Name	Subsite 1		Subsite 2		Total	
		Abun	Freq	Abun	Freq	Abun	Freq
Quadrula asperata	Alabama orb	25.00	40.00	41.67	60.00	34.09	50.00
Fusconaia ebena	Ebonyshell	35.00	50.00	16.67	30.00	25.00	40.00
Obliquaria reflexa	Threehorn wartyback	15.00	30.00	29.17	50.00	22.73	40.00
Ellipsaria lineolata	Butterfly	5.00	10.00	8.33	20.00	6.82	15.00
Truncilla donaciformis	Fawnsfoot	10.00	20.00	0.00	0.00	4.55	10.00
Elliptio crassidens	Elephant-ear	5.00	10.00	0.00	0.00	2.27	5.00
Lampsilis ornata	Southern pocketbook	5.00	10.00	0.00	0.00	2.27	5.00
Quadrula metanevra	Monkeyface	0.00	0.00	4.17	10.00	2.27	5.00
Total species		7		5		8	
Total individuals		20		24		44	
Total samples			10		10		20
Mean density		8.00		9.60		8.80	
Standard deviation		6.17		5.33		7.10	
Menhinik's index		1.56		1.02		1.21	
Species diversity (H')		1.68		1.36		1.63	
Evenness		1.01		0.96		0.86	
% Individuals <30 mm		25.00		4.17		13.64	
% Species <30 mm		28.57		20.00		37.50	

Table A2
Summary Statistics for Data on Freshwater Mussels Collected Using Quantitative Methods at Alabama River Miles 30.1-30.4, September 1998

		Subsite 1		Subsite 2		Total	
Species	**Common Name**	**Abun**	**Freq**	**Abun**	**Freq**	**Abun**	**Freq**
Fusconaia ebena	Ebonyshell	76.19	100.00	52.38	70.00	71.43	85.00
Quadrula asperata	Alabama orb	15.48	60.00	28.57	50.00	18.10	55.00
Obliquaria reflexa	Threehorn wartyback	5.95	50.00	9.52	10.00	6.67	30.00
Ellipsaria lineolata	Butterfly	0.00	0.00	4.76	10.00	0.95	5.00
Quadrula apiculata	Southern mapleleaf	1.19	10.00	0.00	0.00	0.95	5.00
Lampsilis ornata	Southern pocketbook	0.00	0.00	4.76	10.00	0.95	5.00
Plectomerus dombeyanus	Bankclimber	1.19	10.00	0.00	0.00	0.95	5.00
Total individuals		84		21		105	
Total species		5		5		7	
Total samples			10		10		20
Mean density		33.60		8.40		21.00	
Standard deviation		15.79		6.38		17.45	
Menhinik's index		0.54		1.09		0.68	
Species diversity (H')		0.77		1.21		0.91	
Evenness		0.57		0.83		0.57	
% Individuals <30 mm		5.95		28.57		10.47	
% Species <30 mm		40.00		60.00		42.85	

Table A3
Summary Statistics for Data on Freshwater Mussels Collected Using Quantitative Methods at Alabama River Miles 121.8-122.6, September 1998

		Subsite 1		Subsite 2		Total	
Species	**Common Name**	**Abun**	**Freq**	**Abun**	**Freq**	**Abun**	**Freq**
Fusconaia ebena	Ebonyshell	77.63	100.00	78.89	100.00	78.32	100.00
Quadrula asperata	Alabama orb	10.24	100.00	12.44	100.00	11.45	100.00
Obliquaria reflexa	Threehorn wartyback	4.85	70.00	3.56	80.00	4.14	75.00
Ellipsaria lineolata	Butterfly	2.70	70.00	2.44	70.00	2.56	70.00
Fusconaia cerina	Gulf pigtoe	1.62	30.00	1.33	50.00	1.46	40.00
Truncilla donaciformis	Fawnsfoot	1.35	40.00	0.67	30.00	0.97	35.00
Quadrula apiculata	Southern mapleleaf	0.81	20.00	0.44	20.00	0.61	20.00
Leptodea fragilis	Papershell	0.27	10.00	0.22	10.00	0.24	10.00
Plectomerus dombeyanus	Bankclimber	0.27	10.00	0.00	0.00	0.12	5.00
Elliptio crassidens	Elephant-ear	0.27	10.00	0.00	0.00	0.12	5.00
Total individuals		371		450		821	
Total species		10		8		10	
Total samples			10		10		20
Mean density		148.40		180.00		164.00	
Standard deviation		32.47		33.52		35.97	
Menhinik's index		0.52		0.38		0.35	
Species diversity (H')		0.88		0.78		0.83	
Evenness		0.44		0.47		0.45	
% Individuals <30 mm		26.68		24.94		25.73	
% Species <30 mm		60.00		75.00		60.00	

Table A4
Summary Statistics for Data on Freshwater Mussels Collected Using Quantitative Methods at Alabama River Miles 124.4-124.9, September 1998

		Site 1		Site 2		Total	
Species	**Common Name**	**Abun**	**Freq**	**Abun**	**Freq**	**Abun**	**Freq**
Fusconaia ebena	Ebonyshell	78.40	100.00	77.69	100.00	78.08	100.00
Quadrula asperata	Alabama orb	10.80	100.00	12.69	100.00	11.64	100.00
Obliquaria reflexa	Threehorn wartyback	6.17	80.00	6.54	90.00	6.34	85.00
Quadrula apiculata	Southern mapleleaf	1.85	30.00	0.77	20.00	1.37	25.00
Fusconaia cerina	Gulf pigtoe	0.93	30.00	0.77	20.00	0.86	25.00
Ellipsaria lineolata	Butterfly	0.31	10.00	0.77	20.00	0.51	15.00
Truncilla donaciformis	Fawnsfoot	0.31	10.00	0.77	20.00	0.51	15.00
Megalonaias nervosa	Washboard	0.62	20.00	0.00	0.00	0.34	10.00
Leptodea fragilis	Fragile papershell	0.31	10.00	0.00	0.00	0.17	5.00
Quadrula metanevra	Monkeyface	0.31	10.00	0.00	0.00	0.17	5.00
Total individuals		324		260		584	
Total species		10		7		10	
Total samples			10		10		20
Mean density		129.60		104.00		116.80	
Standard deviation		20.84		19.95		23.81	
Menhinik's index		0.56		0.43		0.41	
Species diversity (H')		0.82		0.79		0.81	
Evenness		0.41		0.51		0.47	
% Individuals <30 mm		15.57		18.84		17.12	
% Species <30 mm		50.00		85.71		60.00	

Appendix B
Coordinates for Mussel Beds at Four Locations in the Lower Ohio River, 1998 (Identification numbers correspond to maps on Figures 2 - 8 in the main text)

Table B1
Coordinates for the Mussel Bed Located at River Miles 20.2-20.4, Right-Descending Bank of the Alabama River, Alabama, 1998 (See Figure 3, main text)

Identification Number	Latitude	Longitude	Notes
1	N 31 15.809	W 87 49.896	Downriver of the mussel bed (applies to numbers 1-2)
2	N 31 15.808	W 87 49.910	
3	N 31 15.827	W 87 49.936	
4	N 31 15.848	W 87 49.927	
5	N 31 15.849	W 87 49.895	On the mussel bed
6	N 31 15.882	W 87 49.870	
7	N 31 15.888	W 87 49.888	On the mussel bed
8	N 31 15.900	W 87 49.900	
9	N 31 15.934	W 87 49.844	
10	N 31 15.968	W 87 49.863	On the mussel bed
11	N 31 15.979	W 87 49.871	
12	N 31 16.014	W 87 49.865	On the mussel bed
13	N 31 16.029	W 87 49.864	
14	N 31 15.997	W 87 49.835	
15	N 31 15.970	W 87 49.845	
16	N 31 16.041	W 87 49.852	
17	N 31 16.074	W 87 49.856	
18	N 31 16.128	W 87 49.845	Sand, likely from disposal of dredged material (applies to numbers 18-26)
19	N 31 16.164	W 87 49.835	
20	N 31 16.181	W 87 49.831	
21	N 31 16.210	W 87 49.825	
22	N 31 16.239	W 87 49.810	
23	N 31 16.233	W 87 49.715	
24	N 31 16.181	W 87 49.824	
25	N 31 15.974	W 87 49.775	
26	N 31 15.880	W 87 49.820	

Table B2
Coordinates for the Mussel Bed Located at River Miles 30.1-30.4, Right-Descending Bank of the Alabama River, Alabama, 1998 (See Figure 4, main text)

Identification Number	Latitude	Longitude	Notes
27	N 31 19.765	W 87 46.989	Sand, likely from disposal of dredged material (applies to numbers 27-37).
28	N 31 19.656	W 87 47.076	
29	N 31 19.461	W 87 47.154	
30	N 31 19.264	W 87 47.098	
31	N 31 19.128	W 87 47.021	
32	N 31 20.702	W 87 46.057	
33	N 31 20.497	W 87 46.249	
34	N 31 20.343	W 87 46.442	
35	N 31 20.239	W 87 46.560	
36	N 31 20.116	W 87 46.785	
37	N 31 20.049	W 87 46.923	
38	N 31 20.001	W 87 46.984	
39	N 31 19.961	W 87 46.994	On the mussel bed (applies to numbers 39-55).
40	N 31 19.990	W 87 46.969	
41	N 31 19.904	W 87 47.031	
42	N 31 19.896	W 87 47.039	
43	N 31 19.838	W 87 47.078	
44	N 31 19.802	W 87 47.076	
45	N 31 19.785	W 87 47.101	
46	N 31 19.766	W 87 47.113	
48	N 31 19.633	W 87 47.161	
50	N 31 19.280	W 87 47.180	
51	N 31 19.259	W 87 47.160	
52	N 31 19.291	W 87 47.182	
53	N 31 19.274	W 87 47.164	
54	N 31 19.330	W 87 47.194	
55	N 31 19.620	W 87 47.178	

Table B3
Coordinates for the Mussel Bed Located at River Miles 121.8-122.6, Left-Descending Bank of the Alabama River, Alabama, 1998 (See Figures 6 and 7, main text)

Identification Number	Latitude	Longitude	Notes
1	N 31 58.1784	W 87 24.8124	
2	N 31 58.7898	W 87 27.7206	Natural sandy bank
3	N 31 58.7502	W 87 27.7668	
4	N 31 58.731	W 87 27.8154	Shear rock on shore
5	N 31 58.7682	W 87 27.8562	
6	N 31 58.7796	W 87 27.8226	
7	N 31 58.8042	W 87 27.7812	Bank eroded
8	N 31 58.9668	W 87 27.8982	Left bank eroded
9	N 31 58.959	W 87 27.9216	On mussel bed
10	N 31 58.9362	W 87 27.96	
11	N 31 58.9362	W 87 27.996	Loading dock
12	N 31 59.0214	W 87 28.047	Sand, likely from disposal of dredged material. Small creek enters river.
13	N 31 59.0376	W 87 28.0644	Natural sandy bank
14	N 31 59.0676	W 87 28.0242	
15	N 31 59.088	W 87 27.9576	On mussel bed
16	N 31 59.097	W 87 27.9408	Bank eroded
17	N 31 59.256	W 87 28.0284	
18	N 31 59.2704	W 87 28.0122	
19	N 31 59.2578	W 87 28.035	On mussel bed
20	N 31 59.2452	W 87 28.0812	
21	N 31 59.2452	W 87 28.1472	
22	N 31 59.3622	W 87 28.194	
23	N 31 59.358	W 87 28.1406	
24	N 31 59.3532	W 87 28.1094	On mussel bed
25	N 31 59.3592	W 87 28.1046	Bank sandy but not eroded
26	N 31 59.5242	W 87 28.1298	
27	N 31 59.5254	W 87 28.14	On mussel bed
28	N 31 59.5038	W 87 28.1802	

(Continued)

Table B3 (Concluded)

Identification Number	Latitude	Longitude	Notes
29	N 31 59.4876	W 87 28.2378	Bank vegetated
30	N 31 59.6142	W 87 28.2948	
31	N 31 59.625	W 87 28.2522	
32	N 31 59.6394	W 87 28.2042	Upriver of mussel bed. River gauge at Site 34 = 37.4 (applies to numbers 32-36)
33	N 31 59.655	W 87 28.1736	
34	N 31 59.8128	W 87 28.2126	
35	N 31 59.7948	W 87 28.266	
36	N 31 59.7708	W 87 28.344	

Table B4
Coordinates for the Mussel Bed Located at River Miles 124.4-124.9, Right-Descending Bank of the Alabama River, Alabama, 1998 (See Figure 8, main text)

Identification Number	Latitude	Longitude	Notes
37	N 32 12.102	W 87 27.9486	Boat ramp
38	N 32 11.988	W 87 27.9108	Woody debris on bank
39	N 32 11.556	W 87 27.912	
40	N 32 11.004	W 87 27.903	
41	N 32 12.594	W 87 27.7992	
42	N 32 12.606	W 87 27.7818	On mussel bed
43	N 32 12.498	W 87 27.7554	
44	N 32 12.102	W 87 27.7074	
45	N 32 12.798	W 87 27.5112	Upper end of eroded bank
46	N 32 13.182	W 87 27.5184	
47	N 32 13.458	W 87 27.5454	On mussel bed
48	N 32 13.428	W 87 27.564	Bank not eroded
49	N 32 13.044	W 87 27.6258	Mouth of creek
50	N 32 12.84	W 87 27.609	Past the mussel bed
51	N 32 12.654	W 87 27.6246	
52	N 32 12.264	W 87 27.618	Bank eroded
53	N 32 11.58	W 87 27.8358	Natural bank not eroded
54	N 32 11.772	W 87 27.8736	
55	N 32 11.976	W 87 27.9012	On mussel bed
56	N 32 12.252	W 87 27.9402	Bank partially eroded
57	N 32 11.436	W 87 28.0956	
58	N 32 11.37	W 87 28.0794	On mussel bed
59	N 32 11.214	W 87 28.05	
60	N 32 10.716	W 87 28.0086	Left-descending bank eroded
61	N 32 10.242	W 87 28.0902	
62	N 32 10.668	W 87 28.1322	
63	N 32 10.716	W 87 28.1754	On mussel bed
64	N 32 10.692	W 87 28.17	Right-descending bank nearly vertical

(Continued)

Table B4 (Concluded)

Identification Number	Latitude	Longitude	Notes
65	N 32 9.972	W 87 28.2378	Right-descending bank vertical
66	N 32 9.876	W 87 28.2204	Downriver of mussel bed
67	N 32 9.738	W 87 28.2054	
68	N 32 9.384	W 87 28.17	

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13. ABSTRACT ***(Maximum 200 words)***

In September 1998, detailed studies of freshwater mussels (Family: Unionidae) were conducted at four mussel beds in the Alabama River, located at River Miles (RM) 20.2-20.4, 30.1-30.4, 121.8-122.6, and 124.4-124.9. Studies were done at the request of the U.S. Army Engineer District, Mobile, to obtain information concerning recertification of the operations and maintenance plan and the previously approved maintenance dredging and disposal. Approximately 1,500 mussels representing 13 species were collected using quantitative methods. *Fusconaia ebena* (ebony shell), *Quadrula asperata* (Alabama orb), and *Obliquaria reflexa* (threehorn wartyback) were most abundant and represented 76.2, 12.6, and 5.7 percent of the collection, respectively. Overall species diversity (Shannon's diversity index, H') for each mussel bed, based on 20, 0.25-m^2 samples, ranged from a low of 0.81 at RM 124.4 to a high of 1.63 at RM 20.2. Density at the most downriver two beds was low (less than 25 individuals/m^2), whereas at the two upriver beds it was greater than 100 individuals/m^2. No Federally listed endangered or threatened species were collected, although a fresh-dead inflated heelsplitter (*Potamilus inflatus*), listed as threatened, was collected in 1998 by another worker at the bed located between RM 20.2 and 20.4. Recruitment rates were similar at all locations;

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evidence of recent recruitment was found for *F. ebena, Fusconaia cerina* (Gulf pigtoe), *O. reflexa, Truncilla donaciformis* (fawnsfoot), *Lampsilis ornata* (southern pocketbook), *Ellipsaria lineolata* (butterfly), and *Q. asperata*. The exact location of each bed was mapped using a global positioning system.